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WASTE TO ENERGY IS A SOLUTION FOR MUNICIPAL SOLID WASTE MANAGEMENT AND FOR SUSTAINABLE DEVELOPMENT PRESENT AND FUTURE

Dr. Sudhakar. G[1], Dr. Abraham[2], G. Swarna Latha [3], Dr. T. Damodharam[4]

[1]Assistant Professor, Dept of Environmental Sciences, Loyola Academy Degree and PG College, Secunderabad,
[2]Teaching Assistant, Dept of Environmental Sciences, S.V. University, Tirupathi,
[3] Research Scholar, Dept of Environmental Sciences, Acharya Nagarjuna University, Guntur
[4]Professor, Dept of Environmental Sciences, S.V. University, Tirupathi

Abstract:

Systematic waste management is one of an important issue in present days due to improper waste disposal leads to high environmental risks. It is observed from the exploration that the best and the most feasible waste to energy technology is anaerobic digestion for organic and incineration for plastic waste. This study assesses the different waste-to-energy technologies based on the waste characteristics the emerging technologies are used to produce different by-products such as biogas, heat, electricity, fuel and compost and focus on environmental aspects of optimal disposal and management methods of waste and their compositions in different regions in India for Resource recovery. The waste to energy process should expand to all the regions to meet the sustainable development and energy problems with best practices

Key words: Municipal Solid waste, waste to energy, biogas, heal, Electricity, compost, Resource recovery

Introduction:

Population growth and economic development lead to enormous amounts of waste generation by the dwellers of the urban areas (Karishnamurti and Naidu, 2003; Singh et al., 2011), Waste generation from anthropogenic activities and industrial/agricultural production processes (Xu et al., 2018), adversely affect the natural environment (Kumar et al., 2020), food waste (Xiong et al., 2019), which are normally in solid state known as soild waste, It was identified that the generation of waste continues indiscriminately then the rectification, In developing countries, the scenario is even worse. Collection, transportation and disposal of solid waste are the current challenges (Jacobs 2017; Malinauskaite et al., 2017).In majority of countries most of the smaller units do not have any specific technique of managing these wastes. They pose a threat for health (De Feo and Malvano 2009), and also they may have long term effect on environment (Pattnaik and Reddy, 2009). Land filling due to limited space, emission of greenhouse gases, leachate pollution, etc. (Wambugu et al., 2019). Hence, the management of solid waste has become very important in order to minimize the adverse impacts on the environment (Kumar et al., 2020). Solid waste can be classified as garbage, rubbish, industrial waste (Kumar and Thakur 2018), and agricultural waste. The Garbage refers to the degradable and consists of more organic solid materials like fruit and vegetables. (Unger and Razza 2018), the examples of rubbish wastes are rubber, leather, metals, glass, paper (De Feo and Malvano 2009), ceramics etc. (Xiong et al., 2019). Restricting Food Waste land filling is not only beneficial for the environment but also encourages zero waste approach toward sustainable development (Unger and Razza, 2018). Refuse is very heterogeneous in composition and the geographical, temporal, and seasonal variations in its composition make it difficult to define a typical refuse (World Bank 1994, *Rajasekhar et al 2015*). The solid refuse generated in different areas contains particles of various sizes and types and consists of dust, organic waste like garden waste, vegetable waste etc., (Wang et al., 2020), which are all used for produce energy considered as waste to energy sources, (Kothari et al., 2014), and reduce pollution problems like solar, wind, and other renewable energies (Malinauskaite et al., 2017). The wastes conversion as feed stocks to H_2 and its useful products such as electricity, heat, reduce fossil fuel usage, and greenhouse gas emissions Classifications of solid wastes are proposed here according to the origin wastes: municipal solid waste (MSW), industrial solid waste (ISW), and healthcare solid waste (HSW) The increase in solid waste production has been attributed to the population growth, the expansion of trade, and the increased number of industries (Malinauskaite et al., 2017), The World Bank report that about 1.3 billion tonnes of waste is generated per year in the world; and by 2025 this amount will increase upto 2.2 billion tonnes per year (Hoornweg and P. Bhada 2012), So that, an urgent need for strategies to treat the increasing rate of MSW generation. However, although in developed countries waste is used by a resource to produce energy, heat, A new term of prosumer has emerged attributing to the role of energetic consumers with the potential to be energy producers, predominantly through self-production of renewable energy, storage, energy management and involvement in demand reaction (Jacobs 2017).Thus, municipal solid waste and domestic sewage have practical disposal to cut down the environmental implication. It is generally known anaerobic digestion is a sustainable, cost-effective technology for waste treatment and energy recovery in the form of biofuel (Kothari et al., 2014), Municipal solid waste management (MSWM), a critical element towards sustainable metropolitan development, comprises segregation, storage, collection, relocation, carry-age, processing, and disposal of solid waste to minimize its adverse impact on environment. Unmanaged MSW becomes a factor for propagation of innumerable ailments (Kumar et al., 2009). Managing Municipal Solid Waste is a challenging rather than an opportunity to obtain other commodities such as recycling materials, heat or energy (Portigal and Lee., 2016; Moya et al., 2016).

Waste-to-energy

Many studies have been conducted in the field of waste management (Morrissey & Browne 2004; De Feo and Malvano 2009; Moustakas and Loizidou 2010; Hamad et al., 2013; Hamad et al., 2014; Shrestha et al., 2014; Di Maria et al., 2017; Zafar 2019), have proposed that a sustainable waste management system should be effective and practical in environmental and economic terms, as well as being socially acceptable. In order to provide optimum management of solid offered a set

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of attributes containing technical, economic, environmental and social aspects (Karagiannidis and Moussiopoulos,1998). So its management is very important (Misra 2005, Zafar, 2019) to achieve the sustainable development goals.

Waste to Energy technology was started as the incineration technology which was built in 1903 for the first time in history. MSW can be transformed into energy from various waste to energy conversion processes and most commonly used techniques are thermal treatment technology (thermochemical conversion) and biological treatment technology (biochemical conversion) for converting MSW into energy (Shrestha et al., 2014 and Zafar, 2019). According to Zafar, 2019, it is an applicable for the low moisture content waste whereas biochemical conversion is best option for high moisture content waste such as organic waste (Fig 1).

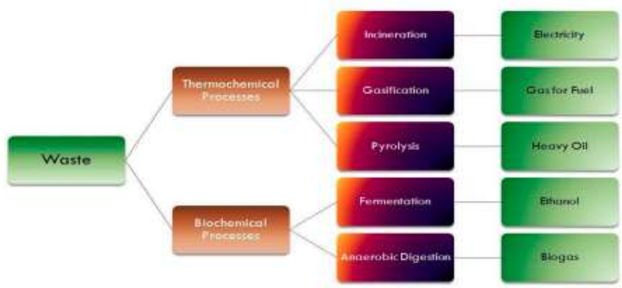

Fig 1: Waste to Energy technology

Biogas production technologies are categorized into ‘wet’ and ‘dry’. Wet technique process have more liquid material whereas dry technique process treat drier materials, in general, ‘wet’ anaerobic digestion technique have been adopted in well-established systems to treat municipal wastewater. The digestion process produces biogas and decontaminated water (Maria et al., 2017). ‘Dry’ anaerobic digestion technologies operate with higher solid content and produce greater heat (Pant et al., 2010). The production of biogas reduces the amount of waste and, therefore, reduces the amount of waste for disposal in landfills. This biogas is usually used in two ways: to generate electricity and to produce heat in different required processes (Bayard et al., 2010). Excess heat can be additionally used in district heating networks or in industrial processes; and future studies regarding the use of biogas as vehicle fuel are expected fuel and compost, in developing countries collection, transport and disposal of waste are current issues (Guerrero et al., 2013, Antizar- Turrion 2010). (Fig 2 & 3)

Fig 2: Anaerobic digestion of Municipal solid waste process (Source Puhler-2010)

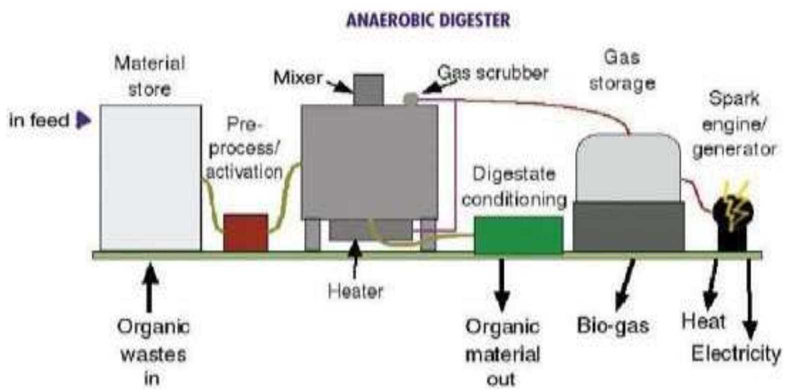

Fig 3: Anaerobic Digestion process and production of Energy

Pyrolysis and gasification technique are used as the alternative to incineration which are thermal treatment process. These processes reduce volume of the waste by converting solid waste into gas or oil followed by the combustion. These processes are regulated in USA and European Union countries as waste incinerators and this process consist of thermal treatment of solid waste and combustion of resulted gases from process both in site or distributed fuel (Tangri and Wilson, 2017). Particularly, gasification process includes decomposition of solid waste requiring high heat which is above 600 degree Celsius in a starved oxygen level (Moustakas and Loizidou, 2010). Likewise, pyrolysis is similar to gasification which also converts waste into oils and gas as well as solid waste outputs in the presence of heat without oxygen supply (Fig 4 & 5). This technology has been testing over 30 years by various companies (Tangri and Wilson, 2017).

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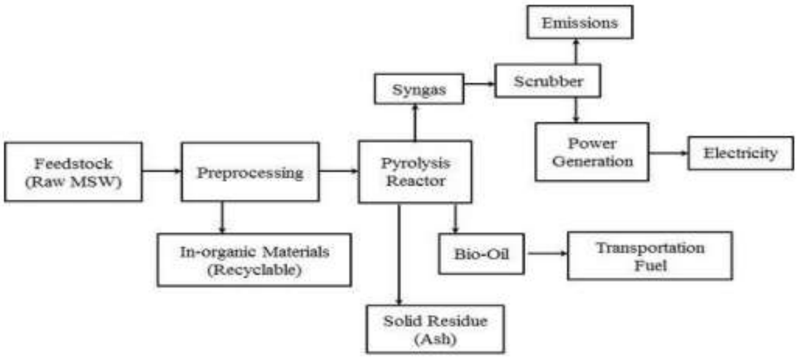

Fig 4: Pyrolysis process flow diagram for municipal solid waste (source Zafer-2009)

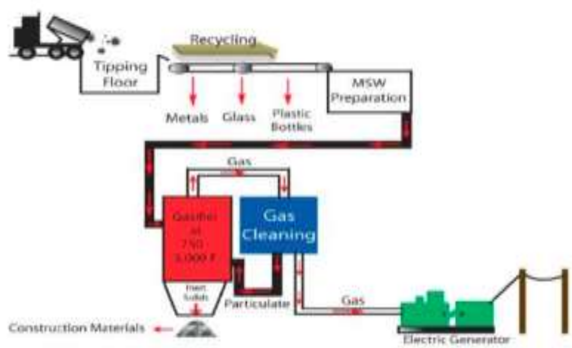

Fig 5: Municipal solid waste Gasification and power generation plant (Source Zafer-2009)

Results and discussion

Source and Composition of Municipal solid waste

The composition of the waste is typically recyclable and non-hazardous and the amount of the waste per capita is less in comparison to developed countries. The main source of municipal solid waste production is households, Commercial, Institutional places (fig 6). The composition of municipal waste are usually organic, plastics, paper and paper products, glass, metals textiles, rubbles and leather and others. The organic waste shares the highest volume in comparison to other waste in the study area (Fig 6 and Tab.1). Nevertheless, the volume and composition of municipal solid waste is governed by living standard and economic status of the community and households.

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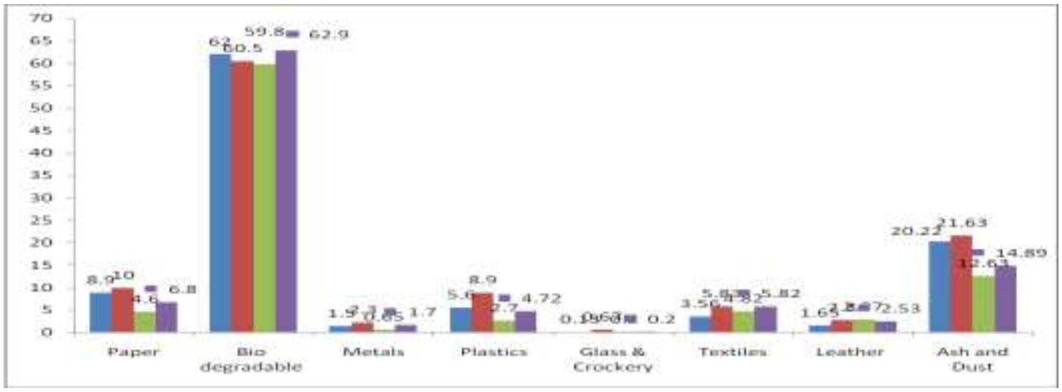

Fig 6: Composition of municipal solid waste in different regions in India

Parameter	New Delhi	Mumbai	Bangalore	Hyderabad
Paper	8.9	10	4.6	6.8
Bio degradable	62	60.5	59.8	62.9
Metals	1.5	2.3	0.65	1.7
Plastics	5.6	8.9	2.7	4.72
Glass & Crockery	0.13	0.67	0.2	0.2
Textiles	3.56	5.83	4.82	5.82
Leather	1.65	2.8	2.87	2.53
Ash and Dust	20.22	21.63	12.63	14.89

Table.1: Composition of Municipal solid waste from Different regions in India

Municipal solid waste has various chemical parameters which indicates the suitability of biogas or gaseous composition such as moisture- 53.96 %, Ash content- 4.96 %, Carbon- 22.36 %, Hydrogen - 3.46 %, Oxygen - 14.62 %, Nitrogen- 0.38 %, Sulfur - 0.15 %, Chloride - 0.11 %, and Energy content is from dry waste is 5,322.44 kcal/kg, wet waste at high value has 2,451.31 kcal/kg, and the wet waste at low value has 1,940.74 kcal/kg. etc,. indicated in Table 3 figure 4. The dry waste has more energy content it will use as biomass energy. The wet waste is suitable for production of biogas. Biogases from anaerobic bio-digestion process can produce heat in a boiler, heat and electricity or vehicle fuel after upgrading and compressing.

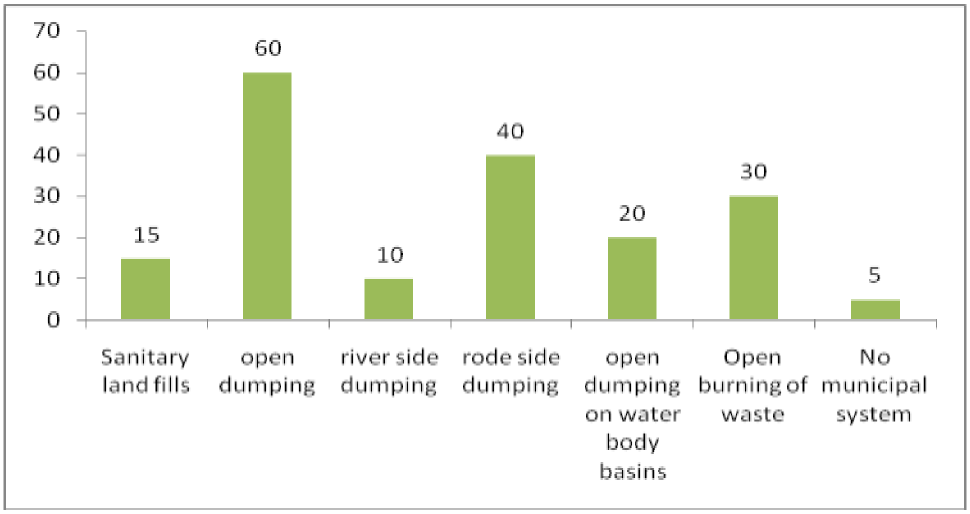

Fig 7: Types of municipal solid waste Disposal methods in India

Table 2: recycle capacity in percentage

S.No	Type of waste	recycle percentage
1	Paper	100
2	Textile materials	40
3	Metals	10
4	Plastics	35
5	Glass	25

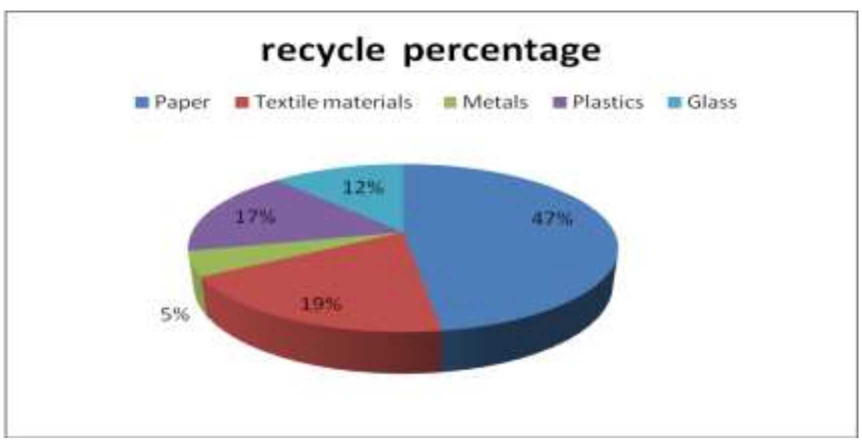

Figure.8: recycle of solid waste materials in percentage

Recyclable Solid waste in different regions is showed in fig 8. Most of the organic solid waste in municipal solid waste is paper 47 %, textile materials 19%, and non degradable waste materials are 12 % of Glass material, 5 % of metals, 17 % of Plastics from the compositions but in the decomposition process the papers is 100% degradable . which is in organic nature, along with the

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paper other organic waste materials are suitable for energy generation purpose based on the compositions (table 3) through various techniques, In fact implementation of recycling or proper disposal of any waste materials is absolutely necessary (Asadi, et al., 1995)

Table 3. Waste category and their compositions

S.No	Waste category	Waste composition
1	Organic matter	Waste from foodstuff (e.g., food and vegetable refuse, fruit peals, litter, corncob, leaves, grass, and manure)
2	Paper/cardboard	Paper, paper bags, cardboard, box board, news papers, magazines, tissue, office paper, and mixed paper (e.g., all papers that do not fit into other categories)
3	Glass	Bottles, glassware, light bulbs, ceramics, and so on
4	Plastic	Wrapping film, plastic bags, polythene, plastic bottles, plastic hoses, plastic strings, and so on
5	Metals	Both ferrous and non-ferrous metals including cans, wire, fence, bottle covers, aluminum materials (e.g., foil, ware, and bimetal)
6	Wood	Products comprised of wood (e.g., tables and chairs)
7	Miscellaneous	Materials comprised of leather, rubber, fiber, textiles, soils, and more (e.g., tires, batteries, large appliances, nappies/sanitary products, medical waste, and so on)

The present data on urbanization and solid waste management in India focused on the upcoming trends of waste to energy process based on the waste characteristics from the sources of waste, clearly depicts that the over population living in urban areas has increased the solid waste management problems and environmental pollution problems, which are directly contributes to health issues an damage the modern urban living so that, on the problem of waste because of leads to water and soil contaminations as well as green house gases into the atmosphere , Hence, the measures should take to control the solid waste and problems associated with it, along with the measures to deal with the waste in healthy and environment friendly manner so that it may prove a resource instead of waste.

The microorganisms activities are important to degrade the organic waste materials from the municipal solid waste compositions, there are various microorganism are identified by the researches such as Hydrolytic bacteria which are Bacteroides, Lactobacillus, Propionibacterium, Sphingomonas, Sporobacterium, Megasphaera, Bifidobacterium were degraded the Simple sugars, peptides, fatty acids through fermentation process, in Acidogenesis method the Syntropic bacteria like Ruminococcus, Paenibacillus, Clostridium are very active to degrade the Volatile fatty acids, in Acetogenesis process the Acetogenic bacteria like Desulfovibrio, Aminobacterium, Acidaminococcus are very active to degrade the Acetic acid (CH_3COOH), (Mostbauer et al., 2013; Andri et al., 2017).

For anaerobic process requires less energy than the aerobic process and creates much lower amounts of biological heat. The biodegradable fraction is converted into a fuel known as biogas (Fricke et al., 2005). This biogas is burned to produce heat and/or electrical energy, in general terms, the biogas (syngas) produced from gasification process is energy-rich and clean enough to produce energy in a gas turbine or engine. However, nowadays, there are eight different reactor technologies for the waste gasification process (rotary kiln; fixed, entrained and fluidized bed; plasma reactor; vertical shaft and moving grate furnace) and different plant configurations (Arena 2012). Gas emissions from municipal landfills around the world are causing global environmental impacts. This biogas is rich in methane which must be used to produce energy and heat in cogeneration plants (Mostbauer et al., 2013). A recent study showed that worldwide landfills produce about 75 billion Nm3 and less than 3% of this potential is used to produce energy or heat (Themelis and Ulloa 2007). Electricity generation is the most common form of energy production today is through well-designed facilities and is as follows: Combined heat and power (CHP) generation, also known as cogeneration, is an efficient, clean, and reliable approach to generating both power and thermal energy from solid waste. When a CHP system designed to meet the thermal and electrical base loads is installed, it can greatly increase a facility's operational efficiency while decreasing its energy costs, and CHP can also reduce greenhouse gasses, which contribute to global climate change. (Moya et al., 2016; Jacobs 2017). The conversion of biogas to electricity via fuel cell technology offers significant increases in efficiency and, hence, is highly sought after technology. Several biogas installations utilize molten carbonate fuel cell technology. However, solid oxide fuel cell technology is thought to be the most promising technology due to its higher power density and its applicability to a wide range of scales.

Using waste as a feedstock for energy production reduces the pollution caused by burning fossil fuels. Traditional incineration produces CO_2 and pollutants. We can observe that biogas from waste landfill contains 55% CH_4 that has a calorific value of 21.5 MJ/ Nm3, while pure CH_4 has a calorific value of 35.8 MJ/Nm3; this is the reason to remove CO_2 from raw biogas. The energy balance of biogas is highly important, which can replace many other form of combustible gas, and illustrates the calorific value that can be replaced by methane. Advanced methods (e.g., gasification, pyrolysis, and liquefaction) have the potential to provide a double benefit: reduced CO_2 emissions as compared to incineration and coal plants and reduced methane emissions from landfills. Landfills require large amounts of land that could be used for other purposes; the incineration of solid waste can generate energy while reducing the volume of waste by up to 80%.

Resource recovery

Resource recovery in municipal solid waste involves with the dispensation of recovering energy or different product from municipal solid waste for another use like manure preparation. This

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approach mainly aims to reduce environmental, economic and social problems in the urban regions. The resource improvements in waste management to recovery of energy through reduce, reuse and recycle which ultimately helps to reduce solid waste and generate energy. If it is not possible the waste should which id highly organic nature is apply to for making manure at households.

Conclusion:

The safe disposal of municipal solid waste is very important to the municipalities, based on the physical and chemical characteristics of the solid waste the biogas, electricity, bio fuels can produce through various processes. The microbial existence and diversity are very important to decomposition of organic solid materials, which reduce the pollution and contamination of surface water and pathological developments. The reviews suggested that solid waste management and biogas production, waste to energy generations were influences the economic and sustainable sources of energy and alternate sources of energy, if can be replace an existing source of energy (nonrenewable) in significant proportions, and reduce the global problems which will raise due to improper management of waste and contamination of water and soil. Finally, the waste to energy process should expand to all the regions to meet the sustainable development and energy problems with best practices. The people should be educated to realize the importance of source segregation at generation point as biodegradables, inert and recyclable material for proper waste management,

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